

INTRAVASCULAR STENT

This Preliminary Amendment is being filed concurrently with an application that is a division of U.S. Ser. No. 13/106,983 filed May 13, 2011, which is a division of U.S. Ser. No. 10/438,687 filed May 15, 2003, which issued as U.S. Pat. No. 7,951,188, which is a continuation of U.S. Ser. No. 09/564,151 filed May 3, 2000, which issued as U.S. Pat. No. 6,616,689, the entirety of each of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

This invention relates to vascular repair devices, and in particular intravascular stents, which are adapted to be implanted into a patient's body lumen, such as a blood vessel or coronary artery, to maintain the patency thereof. Stents are particularly useful in the treatment of atherosclerotic stenosis in arteries and blood vessels.

Stents are generally tubular-shaped devices which function to hold open a segment of a blood vessel or other body lumen such as a coronary artery. They also are suitable for use to support and hold back a dissected arterial lining that can occlude the fluid passageway. At present, there are numerous commercial stents being marketed throughout the world. While some of these stents are flexible and have the appropriate radial rigidity needed to hold open a vessel or artery, there typically is a tradeoff between flexibility and radial strength. What has been needed and heretofore unavailable is a stent which has a high degree of flexibility so that it can be advanced through tortuous passageways and can be readily expanded, and yet have the mechanical strength to hold open the body lumen or artery into which it is implanted and provide adequate vessel wall coverage. The present invention satisfies this need. That is, the stent of the present invention has a high degree of flexibility making it possible to advance the stent easily through tortuous arteries, yet the stent has sufficient radial rigidity so that it can hold open an artery or other blood vessel, or tack up a dissected lining and provide adequate vessel wall coverage.

SUMMARY OF THE INVENTION

The present invention is directed to an intravascular stent which is highly flexible along its longitudinal axis to facilitate delivery through tortuous body lumens, but which is stiff and stable enough radially in its expanded condition to maintain the patency of a body lumen such as an artery when the stent is implanted therein.

The stent of the present invention generally includes a plurality of cylindrical rings that are interconnected to form the stent. The stent typically is mounted on a balloon catheter if it is balloon expandable or mounted on a catheter without a balloon if it is self expanding.

Each of the cylindrical rings making up the stent have a proximal end and a distal end and a cylindrical plane defined by a cylindrical outer wall surface that extends circumferentially between the proximal end and the distal end of the cylindrical ring. The cylindrical rings are interconnected by at least one undulating link which attaches one cylindrical ring to an adjacent cylindrical ring. The undulating links are highly flexible and allow the stent to be highly flexible along its longitudinal axis. The undulating links are positioned substantially within the cylindrical plane of the outer wall surface of the cylindrical rings. The design of the highly flexible interconnecting members and their placement nested within a

W-shaped member provides for uniform scaffolding and a high degree of vessel wall coverage.

The undulating links may take various configurations but in general have a undulating or serpentine shape. The undulating links can include bends connected by substantially straight portions wherein the substantially straight portions are substantially perpendicular to the stent longitudinal axis.

Not only do the undulating links that interconnect the cylindrical rings provide flexibility to the stent, but the positioning of the links also enhances the flexibility by allowing uniform flexibility when the stent is bent in any direction along its longitudinal axis. Further, the cylindrical rings are configured to provide flexibility to the stent in that portions of the rings can flex or bend and tip outwardly as the stent is delivered through a tortuous vessel.

The cylindrical rings typically are formed of a plurality of peaks and valleys, where the valleys of one cylindrical ring are circumferentially offset from the valleys of an adjacent cylindrical ring. In this configuration, at least one undulating link attaches each cylindrical ring to an adjacent cylindrical ring so that the undulating links are positioned substantially within one of the valleys and it attaches the valley to an adjacent peak.

While the cylindrical rings and undulating links generally are not separate structures, they have been conveniently referred to as rings and links for ease of identification. Further, the cylindrical rings can be thought of as comprising a series of U's, W's and Y-shaped structures in a repeating pattern. Again, while the cylindrical rings are not divided up or segmented into U's, W's and Y's, the pattern of the cylindrical rings resemble such configuration. The U's, W's and Y's promote flexibility in the stent primarily by flexing and by tipping radially outwardly as the stent is delivered through a tortuous vessel.

The undulating links are positioned so that the undulating portion is within the curved part of the W-shaped portion which generally increases the amount of vessel wall coverage. Since the undulating portion does not substantially expand (if at all) when the stent is expanded, it will continue to provide good vessel wall coverage even as the curved part of the W-shaped portion spreads apart as the stent is expanded.

The cylindrical rings of the stent are plastically deformed when expanded when the stent is made from a metal that is balloon expandable. Typically, the balloon-expandable stent is made from a stainless steel alloy or similar material.

Similarly, the cylindrical rings of the stent expand radially outwardly when the stent is formed from a superelastic alloy, such as nickel titanium (NiTi) alloys. In the case of superelastic alloys, the stent expands upon application of a temperature change or when a stress is relieved, as in the case of a pseudoelastic phase change.

The number and location of undulating links that interconnect adjacent cylindrical rings can be varied as the application requires. Since the undulating links typically do not expand when the cylindrical rings of the stent expand radially outwardly, the links continue to provide flexibility and to also provide a scaffolding function to assist in holding open the artery. Importantly, the addition or removal of the undulating links has very little impact on the overall longitudinal flexibility of the stent. Each undulating link is configured so that it promotes flexibility whereas prior art links actually reduce flexibility of the stent.

Because of the undulating configuration of the links, the stent has a high degree of flexibility along the stent axis, which reduces the tendency of stent fishscaling. Stent fishscaling can occur when the stent is bent and portions of the